

INSTITUTE OF HYDROLOGY

SOILWATER INFORMATION PROCESSING SYSTEM

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8BB, UK.

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1.0 INTRODUCTION

The suite of programs described in this manual have been adapted for use on an IBM PC microcomputer. The aim of the programs is to provide the researcher with facilities to deal with soil moisture data in a manner which will suit most hydrological requirements; the calculation of soil water potential gradients and soil water fluxes, for example.

The soil moisture data programs will store and process soil water content data collected by the neutron probe method, and soil water potential data measured by manual mercury manometer tensiometers. The user should refer to the appropriate Institute of Hydrology Reports for documentation of these methods.

The programs are designed to be user friendly and only a beginners understanding of computing and a little familiarity with the DOS commands of the IBM PC have been assumed in much of this manual; a detailed knowledge is unnecessary unless it is decided to build on the existing suite of programs with ones own. In that case a knowledge of SSS FORTRAN or IBM BASIC is required. Whilst the new user is advised to read through this manual, except for Section 12, using the various programs with trial datasets is the best way to familiarize oneself with what they have to offer. (Section 12 will only be useful if further programs are to be written.)

2.0 PROGRAM SUMMARY

The programs referred to in this manual are briefly described below. How they work, how to use them and their limitations are detailed in the Sections indicated. The data file nomenclature of the file input and output of each program is also indicated : XXXX represents site number, YR represents year, "unspecified" indicates that the user names the file, "I" indicates an input file, and "O" output.

PROGRAM & FILES	DESCRIPTION
SITDIR O NPXXXX.DAT	Creates a file to store readings from an individual access tube, or the mean of data from several access tubes, and stores the tube directory information; ie. tube no., no. of observations, no. of measurement depths, measurement depths, and calibration codes corresponding to each measurement depth. (Sections 4 and 4.1)
NPROBE IO NPXXXX.DAT	Offers the user a menu and enables the following activities with files created by SITDIR : keyboard entry of neutron probe data, data editing, processing of a set of readings, production of site summary sheets, listing of dates and times of all reading sets in the file, listing of the directory information. (Sections 4 and 4.2)
MEMRSC I Unspecified O NPXXXX.DAT	Enables storage of data from a file holding "raw" neutron probe data recorded by a memory ratescaler and transmitted to the IBM PC, in an NPROBE system file. (Section 6)
NPMEAN IO NPXXXX.DAT	Reads data from up to 8 individual access tube files, calculates a mean volumetric moisture content for each depth, stores the mean data and produces a listing of the processed data. (Section 7)
NCALIB IO NPCAL.DAT	Allows the user to read and edit the contents of NPCAL.DAT which holds soil calibration data for use with the NPROBE system. (Section 5)
TENDIR O NPXXXX.DAT	Creates a file to store data for an individual array of tensiometers, and stores the following directory information about that array : its number, the number of tensiometers, their depths and the zero set correction. (Sections 4 and 4.1)
TENSIO IO NPXXXX.DAT	Presents the user with the following choice of activities relating to files created by TENDIR : Keyboard entry of data, data editing, production of processed data sheets, listing of the dates and times of the reading sets stored in the file, listing of the tensiometer status codes, listing of the directory information. (Sections 4 and 4.3)

ZFPFIND	For periods of up to one year calculates the depth of
I NPXXXX.DAT	divergent and convergent zero flux planes (ZFPs) in a
0 XXXXYR.ZFP	soil profile and stores the depth of the deepest
	divergent ZFP in another file. (Section 8)
FLUX	Calculates evaporation and drainage fluxes for periods
I XXXXYR.ZFP	of up to one year at user specified depths for a site
I 2 Unspecified	where neutron probe, potential evaporation ZFP and
I NPXXXX.DAT	rainfall data are available. A comprehensive listing is
0 XXXXYR.EVA	produced. The data output are stored in one evaporation
0 Unspecified	data file, and a series of drainage data files named by
	the user. (Section 9)
EVAPL	For periods of up to one year calculates actual
I 3 Unspecified	evaporation fluxes for a site at which daily drainage
I NPXXXX.DAT	losses have been measured, e.g. from a lysimeter.
0 XXXXYR.EVA	Potential evaporation and rainfall data are also
	required. A comprehensive listing is produced and the
	calculated evaporation values are stored in a file.
	(Section 10)

3.0 GENERAL POINTS

3.1 Hardware and Software

The programs have been adapted for use on an IBM PC with 128K random access memory, an IBM monochrome monitor, and an Epson type 80 character width printer. They have been prepared using SuperSoft/Small Systems Services FORTRAN IV Extended version 1.04.

Because they are adaptations from other systems rather than programs devised specifically for the IBM PC with SSS FORTRAN, they may not always operate in the most efficient manner. Also, in their preparation a number of short comings were discovered in SSS FORTRAN version 1.04. These have been circumvented by various means. It is probable that some of the "bugs" have been removed from more recent editions of SSS FORTRAN, (version 2.04 at the time of writing).

3.2 File Organisation

SSS FORTRAN permits the use of file names of the form XXXXXXX.EXT. In the following programs a convention has been used for the nomenclature of certain types of data file as follows :

- NPXXXX.DAT- neutron probe data file for access tube no. XXXX;
- TDXXXX.DAT- tensiometer data file for tensiometer array no. XXXX;
- XXXXYR.ZFP- zero flux plane depth data for tensiometer array no. XXXX and year YR;
- XXXXYR.EVA- actual evapotranspiration data calculated by program FLUX for site no. XXXX and year YR.

Throughout these programs it has been assumed that all data files required by the programs are available on the currently selected drive and all new files are created on this drive. It should be noted that disk files are not inviolate and frequent backing up of files is advisable. Good practice would be to back up a file immediately any alteration is made to the data within it. If the data files are organised in directories (see below), this is easier, for a whole directory may be copied to a diskette in one operation.

If files are kept on a hard disk the various options of the fixed disk backup DOS command, BACKUP, could be explored. They include the facility to backup only those files in a directory which have been modified since the previous occasion BACKUP was used. Whichever method is used, it is important that it is used frequently, and that where, how and when is well documented so that in the event of a hard disk failure, the files can be retrieved easily.

One constraint of SSS FORTRAN 1.04 is that it does not permit full use of the tree structuring facilities for file organisation of IBM PC DOS 2.0. It is not possible from within a program to read or write to a file in another directory. Thus one must work from within the directory in which copies of the data files to be used by a program are available. A possible method of organising data and programs is illustrated below.

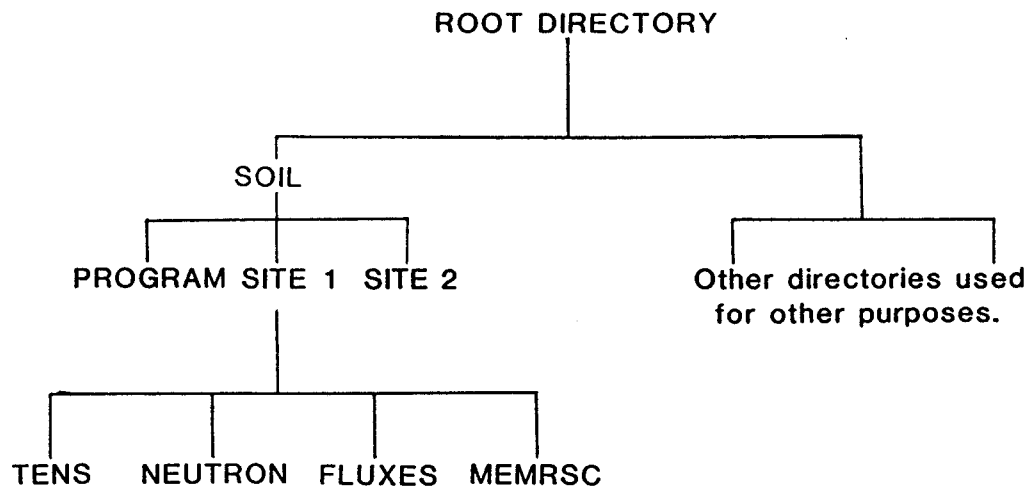


Figure 1. Tree structure of file directories.

The sub-directories would hold the following files :

- PROGRAMS - the executable versions of all the programs;
- TENS - all tensiometer data files associated with Site 1 and ZFP depth files generated by ZFP, the latter would be copied to FLUX when using program FLUX.
- NEUTRON - all probe data files generated by the NPROBE system and NPMEAN, and CALIB.DAT, the calibration data file.
- MEMRSC - all "raw" probe data files transmitted from the memory ratescaler, these would be temporarily copied to NPROBE when running program MEMRSC.
- FLUXES - copies of all input data required for FLUX program, and files output therefrom.

The DOS CHDIR command would be required to enter any given directory,

eg. A>CHDIR \SOILMET\SITE1\FLUXES

and the COPY command to copy files from one directory to another,

eg. A>COPY \SOILMET\SITE1\TENS\FILE.EXT FILE.EXT

This command will copy the named file from the TENS directory to the current directory.

3.3 Running Programs

Switch on the IBM PC. Move the printer paper to the head of of a new page and switch on the printer. Enter the current date and time when requested, then use the CHDIR command to move to the directory containing the files with which one wishes to work. If a copy of the required program is not held in that directory, use the PATH command so that it can be located from within the current directory,

eg. A>PATH \SOIL\PROGRAMS

The required program may then be run by entering its name,

eg. A>NPROBE

will start NPROBE. The prompts from the programs then guide the user as to when to enter further information, for example site numbers, file names and whether or not a printout is required.

3.4 Problems which could occur

a. FILE DOES NOT EXIST, or a similar message will appear when a program is unable to locate a data file in the current directory. If the file exists elsewhere, copy it to the current directory and re-run the program.

b. Write fault error writing device PRN
Abort, Retry, Ignore

This statement occurs if a program is attempting to write to the printer but it is not switched on. Switch on the printer and enter R (for Retry), and the program should proceed.

c. It is possible to stop a program in the middle of a run using the CTRL BREAK command. Simply press the two keys, CTRL and BREAK at the same time. However programs should be allowed to terminate themselves to ensure that all data files are updated and closed correctly. The STOP options in NPROBE and TENSIO should always be used. Should for any reason a program stop prematurely without producing a A>, ie. if a program hangs, the only way to proceed is to remove any diskettes then switch off.

d. PROBLEMS OPENING/CLOSING FILE or a statement to that effect could occur. It means that the required file has been located, but that it may have been corrupted. If another copy of the file is available, copy it to the directory and try re-running the program.

4.0 NPROBE AND TENSIO

Two similar systems for storing and processing neutron probe and tensiometer soil moisture data, NPROBE and TENSIO, respectively have been developed. They are designed for the researcher wishing to process, store and manipulate manually collected neutron probe and tensiometer data, and data recorded using the Wallingford neutron probe memory rate-scaler. Each provides a simple method of :

- a. entering data into files for storage, enabling checking that the correct values have been entered whilst doing so;
- b. processing the data;
- c. subsequently editing and/or reprocessing the data;
- d. subsequently using the stored data in other programs, eg graph plotting.

Both systems assign one file per soil moisture measurement profile, ie per neutron probe tube or tensiometer array. The name of the file incorporates the tube/array number, which may be up to 4 digits long, thus :

NP1234.DAT for neutron probe tube no. 1234
TD5678.DAT for tensiometer array no. 5678.

The files are of a type known as random access, which means that they may not be simply modified with the IBM PC editor, EDLIN, which protects them to some extent. They also have the significant advantage of being quick to work with. NPROBE and TENSIO have been designed to allow maximum flexibility when data editing is necessary.

A random access file is comprised of a series of records, the length and format of which is determined by the user when initially creating the file. In the files created for use with NPROBE and TENSIO the first 2 records are always reserved to store key information about the tube/array and are known as the file directory. In NPROBE this information comprises :

- RECORD 1 - the tube no.;
- the number of records of data presently stored in the file, NREC;
 - the number of measurement depths;
 - the actual measurement depths;
- RECORD 2 - the type of data, ie single or mean tube data, ITYP;
- the maximum number of records which may be stored in the file, MAX;
 - if it is a mean tube file, the nos. of the tubes from which the mean data are usually taken;
 - the calibration codes corresponding to the measurement depths.

In TENSIO the information in the file directory is arranged as follows :

- RECORD 1 - the array no.;
- the number of records of data presently stored in the file, NREC;

- the zero set correction;
- the number of tensiometers in the array;
- the depths of the tensiometers;

RECORD 2 - the maximum number of records which may be stored in the file.

The length and format of the remaining records in any one file is always the same. Each holds the data for one set of neutron probe or tensiometer readings. The actual lengths of both the directory and the data records is determined by the number of measurement depths. However the actual number of measurement depths cannot exceed a maximum of 33 for neutron probe data, and 29 for tensiometer data because there is a constraint on record size imposed by the SSS FORTRAN Compiler.

Figure 2 illustrates the record formats which would be used with NPROBE for a neutron probe tube where measurements are made at 10 depths and a tensiometer array comprising 8 tensiometers at different depths. It should be noted that the data are stored as measured in the field, ie, as neutron count rate or mm mercury on the manometer scale. In the case of the neutron probe data, the integration time and a neutron count rate measured in a water standard are also stored for each reading occasion.

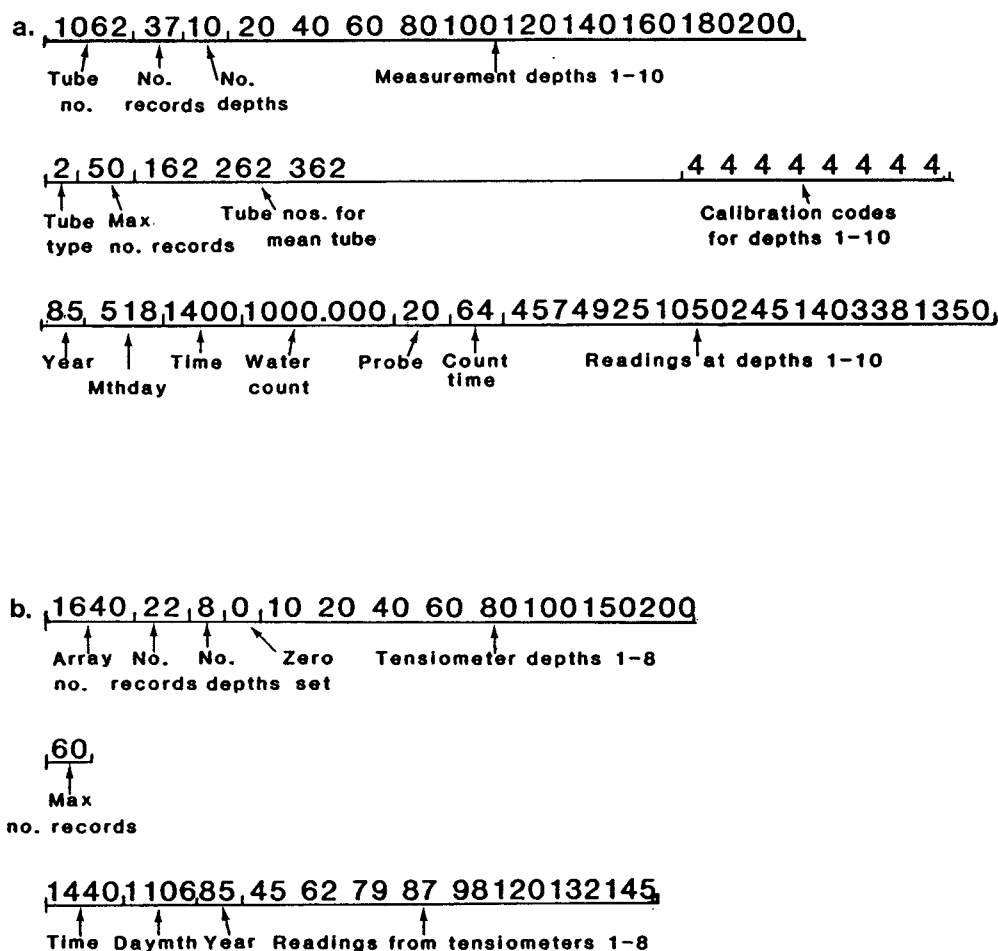


Figure 2. a. Neutron probe data file format, first, second and remaining records.
b. Tensiometer data file format, first, second and remaining records.

NREC, the number of records of field measurements stored in a file is always updated when more data are added to, or a record is deleted from a file. The data are entered in chronological order by the user. The editing facilities enable resequencing if necessary, as well as modifications to, or deletion of, individual records, if they are found to be incorrect.

4.1 Running SITDIR AND TENSIO

NPROBE and TENSIO have companion programs, SITDIR and TENDIR which are used whenever a file is created to hold data for a given tube/array. They enable entry of the directory information. Thereafter they are not required.

These two programs request the directory information about the neutron probe tube, or tensiometer array as follows :

- the tube or array no.;
- the number of measurement depths;
- the actual measurement depths;
- the maximum number of sets of observations which will be stored in that file;
- if it is a neutron probe data file, whether it is to hold data for a single access tube, or for a "mean" tube;
- if it is a neutron probe data file, the calibration codes corresponding to the measurement depths;
- if it is a tensiometer data file, the zero set correction.

A file is then created whose name incorporates the tube/array no.. The number of records is determined by the user, and the record lengths are determined by the number of measurement depths. The directory information is stored in the first 2 records.

In entering the directory information, the following points should be noted.

* The tube or array no. may be up to 4 digits long and must be entered as 4 digits, ie. if the tube no. is 4, enter 0004 which will result in a file called NP0004.DAT. If just 4 is entered the file name generated will be NP4000.DAT.

* The number of depths cannot exceed 33 for a neutron probe data file, or 29 for a tensiometer data file.

* The depths are entered in depth order, the shallowest first, in units of centimetres.

* The maximum number of observations to be stored in this file determines how large a file will be created. If weekly readings are to be made over a period of a year, 52 sets of observations will be recorded, thus 52 could be entered. However, it would be wiser to enter 60 to allow for a few extra readings. The file cannot be enlarged later and so it is better to err on the generous side.

* The neutron probe soil calibration codes : see Section 5.

* Is the neutron probe data file for single access tube or "mean" tube data ? The user indicates which, and if "mean" tube is specified, is then requested to supply the nos. of the access tubes from which the mean data will normally be generated. These numbers should be entered as 4 digits each, as above. If the file is to be for mean tube data, the calibration code 4 must be used for all depths.

* The tensiometer zero correction factor is required because it is not always possible in the field to adjust the height of the scale on the mercury manometer board such that the zero on the board corresponds to the height of the mercury columns when the hydraulic potential is zero. Thus the necessary correction \pm mm mercury can be stored in the file directory and is referred to when soil moisture potentials are calculated from field readings.

4.2 Running NPROBE

The main neutron probe data processing program can carry out several functions. On starting it running requests a site number and then offers the menu below :

1. ENTER NEW DATA
2. SUMMARISE READING DATES
3. DELETE DATA
4. INSERT DATA
5. MODIFY DATA
6. DATA SHEET
7. SITE SUMMARY SHEET
8. SITE DIRECTORY
9. SELECT ANOTHER SITE
0. STOP

The user selects an option which the program then executes. When that is complete the program returns to the menu so that more work may be performed with data from the same access tube, another tube selected, or the run terminated.

Several of the options require the user to specify which neutron probe reading occasion is required. As the data are stored on a one record per set of readings basis, any occasion can be specified by reference to the corresponding record number. Option 2 allows checking of record numbers.

1. ENTER NEW DATA

This permits neutron probe data to be added to the end of the data already stored in the file. After data entry, an opportunity to correct it is given prior to storage and printing of a data sheet (Fig.3).

2. SUMMARISE READING DATES

A list of all the dates and times for which neutron probe data are currently stored is provided on either the screen or the printer, as chosen by the user (Fig.4). They are listed with the numbers of the records in which the data for each reading occasion are stored.

3. DELETE DATA

This option enables deletion of the data stored for one reading occasion. The data to be deleted are identified by the number of the record in which they are stored. The remaining records in the file are

automatically renumbered after a deletion.

4. INSERT DATA

Similar to option 3, this allows one to insert data AFTER any record in the file. The user indicates the record number.

5. MODIFY DATA

The user specifies which set of data is to be modified by entering its record number, and then any of the data stored for that reading occasion may be altered as in option 1.

6. DATA SHEET

The user enters the record number of the reading occasion for which a data sheet is required (Fig.3).

7. SITE SUMMARY SHEET

The user indicates whether a summary of all the data stored in the file is required, or a summary of only part of it. If the latter, the numbers of the first and last records of the sequence for which a summary is required is entered. Fig.5 illustrates a site summary sheet.

8. SITE DIRECTORY

The information regarding calibration constants and measurement depths stored for the given access tube number is listed (Fig.6).

9. SELECT ANOTHER SITE

This option the file currently open, and the program returns to the beginning to request the number of the next access tube.

0. STOP

This option closes any open files and terminates the run. It is advisable always to end a session with this option rather than just switching the computer off, as files which have not been closed properly can cause problems.

4.3 Running TENSIO

This system is very similar to NPROBE. Initially the user is requested to supply the number of the tensiometer array for which data are to be handled. The corresponding file is opened and the user selects from the following menu :

1. ENTER NEW DATA
2. SUMMARISE READING DATES
3. DELETE DATA
4. INSERT DATA
5. MODIFY DATA
6. PROCESS DATA
7. LIST STATUS CODES
8. SITE DIRECTORY
9. SELECT ANOTHER SITE
0. STOP

The options, but for 7, are very similar to those in NPROBE. The data output are illustrated in Figs.7 to 9.

ACCESS TUBE NO. 1158 DATE 15 383

PROBE NO. 160 WATER COUNT 955.0 COUNT TIME 64SEC READING TIME 935

DEPTH CM	READING	MVF	LAYER CM	WATER IN LAYER MM	CUM	CHANGE SINCE LAYER MM	8 383/ 935 CUM
10	373	.285	0 - 10	28.5	28.5	-1.2	-1.2
20	375	.286	10 - 20	28.5	57.0	-1.2	-2.4
30	382	.292	20 - 30	28.9	85.9	-1.1	-3.4
40	414	.318	30 - 40	30.5	116.4	-.8	-4.3
50	441	.341	40 - 50	33.0	149.4	-.5	-4.8
60	409	.314	50 - 60	32.8	182.1	-.1	-4.8
80	385	.294	60 - 80	60.9	243.0	-.2	-5.0
100	363	.276	80 - 100	57.1	300.1	-.5	-5.5
120	425	.328	100 - 120	60.4	360.5	-.4	-5.9
140	407	.313	120 - 140	64.0	424.5	.1	-5.8
160	409	.314	140 - 160	62.7	487.2	-.2	-6.0
180	406	.312	160 - 180	62.6	549.8	-.5	-6.5
200	402	.309	180 - 200	62.0	611.9	.3	-6.2
220	437	.337	200 - 220	64.6	676.5	-.2	-6.3
240	495	.385	220 - 240	72.3	748.8	-.1	-6.4
260	516	.403	240 - 260	78.8	827.6	.7	-5.7
280	522	.408	260 - 280	81.1	908.7	.1	-5.6
300	526	.411	280 - 300	81.9	990.6	.2	-5.4
330	510	.398	300 - 330	121.4	1111.9	.6	-4.8
360	531	.415	330 - 360	122.0	1233.9	-.4	-5.2
390	534	.418	360 - 390	124.9	1358.8	-1.1	-6.3
420	531	.415	390 - 420	124.9	1483.8	-.5	-6.8
450	521	.407	420 - 450	123.3	1607.1	.2	-6.5
470	499	.389	450 - 470	79.6	1686.7	-.5	-7.0

DATE PRINTED 23- 6-1987

Figure 3. PROBE data sheet

SUMMARY OF NEUTRON PROBE READING DATES AND TIMES FOR
MEAN TUBE NO. : 3040

NO.	DATE	TIME
1	10 584	1200
2	11 584	1205
3	12 584	1250
4	13 584	1425
5	14 584	1430
6	17 584	1140
7	1 684	1250
8	7 684	1425
9	14 684	1140

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Figure 4. Summary of readings sheet.

SOIL MOISTURE SUMMARY FOR ACCESS TUBE NO. : 1158

MOISTURE VOLUME FRACTIONS AND TOTAL PROFILE MOISTURE CONTENTS

DEPTH CM	10	20	30	40	50	60	80	100	120	140	160	180
17 583	.328	.311	.317	.340	.352	.319	.310	.286	.331	.316	.318	.310
24 583	.328	.311	.316	.338	.348	.318	.302	.285	.329	.316	.314	.311
2 683	.324	.318	.322	.345	.358	.324	.309	.294	.335	.318	.316	.312
7 683	.288	.294	.297	.324	.347	.314	.298	.279	.334	.312	.320	.316
14 683	.222	.263	.283	.302	.335	.307	.288	.273	.326	.311	.316	.316
21 683	.169	.223	.256	.286	.321	.304	.282	.271	.319	.312	.315	.320
28 683	.146	.199	.234	.272	.311	.301	.274	.269	.314	.308	.316	.313
5 783	.159	.199	.228	.263	.303	.295	.274	.269	.312	.304	.314	.309
MEAN VAL	.246	.265	.282	.309	.334	.310	.292	.278	.325	.312	.316	.313

DEPTH CM	200	220	240	260	280	300	330	360	390	420	450	470
17 583	.307	.343	.385	.398	.405	.407	.394	.414	.419	.412	.403	.393 1704.069
24 583	.305	.343	.382	.400	.405	.408	.402	.416	.419	.415	.407	.392 1705.184
2 683	.306	.343	.385	.404	.413	.412	.403	.411	.422	.418	.406	.394 1718.744
7 683	.305	.341	.382	.404	.409	.412	.398	.419	.425	.419	.408	.397 1698.953
14 683	.305	.342	.379	.397	.407	.408	.397	.416	.426	.411	.408	.396 1667.592
21 683	.302	.332	.376	.400	.405	.410	.395	.420	.421	.411	.407	.395 1643.256
28 683	.304	.334	.379	.398	.407	.407	.402	.416	.421	.418	.407	.392 1631.026
5 783	.302	.331	.374	.397	.405	.407	.392	.413	.422	.409	.405	.390 1619.126
MEAN VAL	.304	.339	.380	.400	.407	.409	.398	.416	.422	.414	.406	.394 1673.494

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Figure 5. Site summary sheet.

DIRECTORY INFORMATION FOR ACCESS TUBE NUMBER 1158

TOTAL NO. OF MEASUREMENT DEPTHS : 24

MEASUREMENT DEPTHS (in cm), AND CALIBRATION CODES

1	10	1	13	200	1
2	20	1	14	220	1
3	30	1	15	240	1
4	40	1	16	260	1
5	50	1	17	280	1
6	60	1	18	300	1
7	80	1	19	330	1
8	100	1	20	360	1
9	120	1	21	390	1
10	140	1	22	420	1
11	160	1	23	450	1
12	180	1	24	470	1

PRESENT NO. OF PROBE DATA RECORDS : 30 POTENTIAL NO. : 50

ENTER C WHEN READY TO CONTINUE >

Figure 6. Site directory listing.

7. LIST STATUS CODES

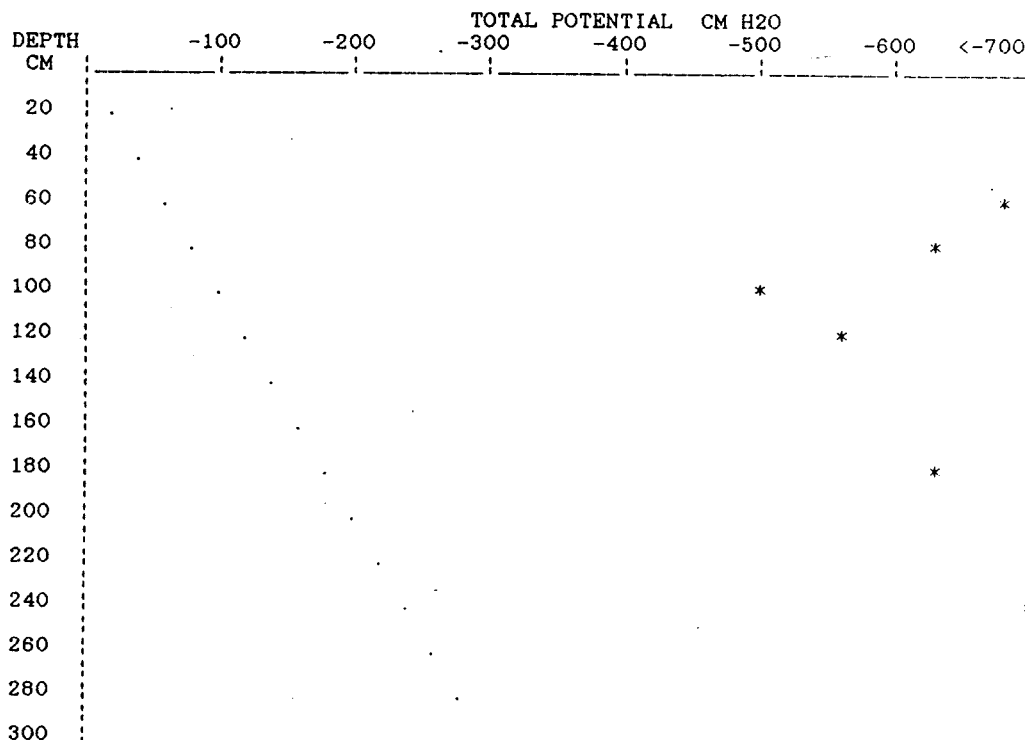
This option provides a list of the meaning of the tensiometer status codes. They are also listed below.

- 0 (Or blank) Functioning correctly
- 1 Air bubbles in tube or mercury trap
- 2 Breaks in mercury column
- 3 Estimated reading
- 4 Tensiometer not working
- 8 Tensiometer purged since last reading
- 9 Frost

TENSIOMETER SET NO. 1152

DATE : 9 685 TIME : 1200 OBS.NO : 3

DEPTH CM	READING MM HG	STATUS CODE	MATRIC POT CM H2O	TOTAL POT CM H2O	GRADIENT AT DEPTH CM
20	604	0	-738.6	-758.6	.000
40	583	0	-692.2	-732.2	-1.319
60	540	0	-618.2	-678.2	-2.700
80	500	0	-548.0	-628.0	-2.512
100	400	0	-402.4	-502.4	-6.280
120	442	0	-435.2	-555.2	2.638
150	460	0	-427.8	-577.8	.754
180	499	0	-446.7	-626.7	1.633
210	510	0	-430.6	-640.6	.461
240	560	0	-463.4	-703.4	2.093
270	598	0	-481.1	-751.1	1.591
300	610	0	-466.2	-766.2	.502



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Figure 7. TENSIO data sheet.

SUMMARY OF TENSIO METER READING DATES AND TIMES FOR
TENSIO METER SET NO : 1152

NO.	DATE	TIME
1	6 685	1200
2	7 685	1200
3	9 685	1200
4	14 685	1400
5	16 685	1500
6	20 785	1330
7	20 785	1400
8	24 785	1230

PRINTED ON 23 6 1987

Figure 8. Summary of readings sheet.

DIRECTORY INFORMATION FOR TENSIO METER SET NUMBER 1152

ZERO SET CORRECTION : 0 CM

TOTAL NO. OF MEASUREMENT DEPTHS : 12

MEASUREMENT DEPTHS IN CM :

1	20	7	150
2	40	8	180
3	60	9	210
4	80	10	240
5	100	11	270
6	120	12	300
7	150		

PRESENT NO. OF RECORDS : 8 POTENTIAL NO. : 70

ENTER C WHEN READY TO CONTINUE >

Figure 9. Site directory listing.

5.0 NCALIB

NPROBE refers to a random access file called NPCAL.DAT every time a neutron probe data file is opened for data processing. This file holds the soil moisture calibrations for neutron probe data and corresponding calibration code numbers. NCALIB permits the user to enter his own calibrations, with corresponding code numbers, into NPCAL.DAT. Alternatively, it may be necessary to alter or delete a calibration.

Four calibrations, code numbered 1 to 4, are held in the first 4 records of the file and cannot be changed. These are the 3 basic Institute of Hydrology calibrations, (see IH Report No.19), and number 4, a dummy calibration for use with mean tube data :

Code no.	Slope	Intercept
1.	0.79	-0.024
2.	0.867	-0.016
3.	0.958	-0.012
4.	1.000	0.0

The slope and intercept are defined by $\theta = \text{slope} \frac{R}{R_w} + \text{intercept}$ where

R = count rate and R_w = water count rate. It is essential that the calibration codes are entered in sequential order for the program uses a code number to locate the record in which a corresponding calibration is stored. Up to 99 calibrations may be held in the file. Such a large number should give plenty of flexibility. Great care should be taken if it becomes necessary to modify or delete a calibration in the file for doing so can easily upset data processing by another user who is unaware that a change has been made.

5.1 Running NCALIB

A short menu is offered initially :

1. LIST THE EXISTING CALIBRATIONS
2. ADD ADDITIONAL CALIBRATIONS
3. CHANGE OR DELETE A CALIBRATION
4. STOP

If option 3 is selected, the user is advised of the hazards of making changes to the calibration file and is given the opportunity to have second thoughts.

6.0 MEMRSC

This program uses neutron probe data automatically logged by a memory ratescaler then transmitted to a file on the IBM PC using the unformatted data transmit mode of the ratescaler. The arrangement of the data in the memory ratescaler file is described in the manual supplied with the ratescaler.

MEMRSC reads the file of "raw" data looking through the continuous string of ASCII characters for an end of readings marker "E". The string preceding the "E" is then divided into the date, time, tube no., probe no., count time, depths and readings recorded at that access tube by the ratescaler. The opportunity is given to skip over this set of readings and continue to the next set, in which case the same process is repeated. Otherwise the program searches for the corresponding NPROBE system data file, checks whether data recorded for the same date, or a later date, have already been stored, and if not, stores the new set of readings. If it finds that data have already been stored for the same date and time, it closes the probe data file, and passes to the next reading set in the memory ratescaler data file. Similarly, if it is unable to find the appropriate neutron probe data file, it passes on to the next reading set having indicated why. After dealing with each set of readings, the user can opt to process them and produce a listing immediately.

6.1 Running MEMRSC

The program requests the name of the file containing the memory ratescaler data. The program prompts guide the user through the remainder of the program. One is asked to supply standard water counts for the data sets in the memory ratescaler file.

7.0 NPMEAN

The NPMEAN program enables the mean of neutron probe readings from several access tubes to be calculated and stored in a file which is compatible with the NPROBE system. The NPROBE system treats data in such a file in exactly the same way as those from a single access tube.

The user must initially use SITDIR to create a file for mean tube data storage. Calibration code 4 must be entered for every measurement depth when doing so. The file created is flagged to indicate that it is a mean tube file, and also holds the numbers of the access tubes from which the mean data is usually derived. If the user wishes to enter data from fewer tubes, this is permitted, though not recommended.

NPMEAN can calculate and store the mean of data from up to 8 tubes. The user is asked to enter the dates and times of the reading occasions for which data are to be calculated. Up to 10 different occasions may be dealt with at one time if entered in chronological order. The program can only add data to the end of the mean tube file. If it is necessary to insert data recorded on an earlier occasion than the last observation set in the file, or to modify a set of observations, the user should use the appropriate NPROBE options having manually calculated the mean values and assuming a water count of 1000.

The data stored are a mean of the MVFs calculated for each depth in the individual profiles and converted to represent a count rate with a water count of 1000, assuming a calibration of slope 1.0 and intercept 0.0. For example MVFs of 0.321, 0.340 and 0.335 might have been recorded in three access tubes. Their mean MVF is 0.339. NPMEAN converts this to a count rate of 339 and stores it. In any operation by NPROBE on the data:

$$\text{MVF} = 339/1000 * 1.0 + 0.0 = 0.339$$

At run time, the user is asked to enter a time over which the readings at the several access tubes may span. For example, data from a set of tubes which take 4 hours to read in total may be being computed. In that case, the span time would be +/- 2 hours if the reading time entered is in the middle of that period. If the tubes took from 0900 to 1300 to read and a reading time of 1100 and span time of 2 hours is entered, all the data will be included. However, should a reading time of 0900 and a span time of 2 hours be supplied, only those tubes read before 1100 will be included in the computation. The reason for supplying this information is to prevent the program confusing data where several sets of readings have been made in the course of a day.

The number of depths in the individual access tubes must be the same, or greater than the number stored in the mean tube file. The measurement depths down to the maximum depth of the mean tube data must be the same for each of the individual access tubes. SITDIR does not check that this is so, but if it is not, NPMEAN will stop, indicating why, on the first attempt to run it.

7.1 Running NPMEAN

The user is requested to supply the mean tube number, the numbers of

the single access tubes for which data are to be extracted, and the dates and times of the reading occasions for which the calculation and storage are to be performed.

8.0 ZFPFIND

ZFPFIND calculates the depths of any divergent and/or convergent zero flux planes, if present, in a soil profile, using a paraboloidal fit to tensiometer measurements of soil water potential in the profile. The program uses files generated by the TENSIO system. The calculations are made for the first set of readings of the day, on all the days of a specified year, for which data are available. The depth of the deepest ZFPs are stored in a sequential file in a format which is compatible with the FLUX program. The file name is of the form XXXXYR.ZFP where XXXX is the number of the tensiometer array for which the ZFP depths have been calculated, and YR the year for which the data in the file have been computed. Fig.10 illustrates the output from ZFPFIND.

The program searches the tensiometer data file for the first occasion when a ZFP is present, either divergent or convergent. It should be noted that if more than one set of readings have been stored on a given day, only the first set of readings are searched, the later ones are ignored. Also, in making the search, any tensiometer measurements of zero or flagged with status code 4 (tensiometer not working) are ignored.

A paraboloidal fit is used to determine the position of the ZFP, and any others deeper in the profile. The position of all the ZFPs in the profile on a given day are recorded on the printout and the depth of the deepest divergent one is stored in the file. The tensiometer readings for the next reading date are similarly dealt with. Then, for the days between the two measurement dates, a linear interpolation procedure is used to estimate the position of the deepest divergent ZFP. If there is no ZFP on the first or second days of a pair of corrective readings it is assumed that no ZFP exists in the time between them.

8.1 Running ZFPFIND

The program requests the user to supply the number of the tensiometer array and the year for which the program is to be run.

DAY NO	M	M	M	M	M	DATE
157	D	.843				6 685
158	D	.849				7 685
159	D	1.041				9 685
165	C	.764	D 1.040			14 685
167	C	.613	D 2.601			16 685
201	D	.891				20 785
205	D	.599				24 785

LIST OF FILE Z1152/85.DAT (DAY NUMBERS ARE NOT PART OF FILE)
CREATED ON 23- 6-1987

1152	85																	DAY		
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20		
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40		
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	60		
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	80		
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100		
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	120		
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	140		
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	84	85	95	104	160
104	104	104	104	104	182	260	255	250	245	240	235	230	225	220	215	210	205	200	195	180
190	185	180	175	170	165	160	155	150	145	140	135	130	125	120	115	110	105	100	95	200
89	82	75	68	60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	220
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	240
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	260
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	280
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	300
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	320
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	340
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	360
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	386

Figure 10. ZFPFIND data output.

2	1158	83																	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	32	32	32	33	44	37	35	35	35	36
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	32	38	0	0	0	0	0	0	0	0	35	42	45	48
60	63	66	70	67	76	79	81	93	105	117	123	129	132	133	135	137	138	139	141
141	142	142	142	143	143	144	144	144	143	142	142	145	146	148	150	152	154	156	153
153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153
153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153
153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153
153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153
153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153
153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153
153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153
153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153
153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153
153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153

Figure 11. ZFPFIND data file.

9.0 FLUX

Program FLUX calculates soil water balances for specified periods and depths, given rainfall, zero flux plane depths, potential evaporation values and probe readings. Up to one year's worth of data may be processed at a time. A listing (Fig.15) is produced and also a file holding the calculated evaporation output, and one or more files holding the calculated drainage values corresponding to the depths specified (Figs.16 and 17).

The program reads values of daily rainfall, ZFP depths, evaporation and neutron probe readings. If more than one set of neutron probe data are available for one day, the first set of readings recorded on that day are used in the calculations. If the ZFP depth is zero, the program calculates drainage at a specified depth z , as :

$$\begin{aligned} \text{drainage} = & \text{cumulative rainfall} - \text{cumulative evaporation} \\ & - \text{changes in moisture content of soil down to} \\ & \text{depth } z. \end{aligned}$$

If the ZFP depth is greater than zero, the evaporation in the input data is ignored and instead evaporation is calculated as :

$$\begin{aligned} \text{evaporation} = & \text{cumulative rainfall} - \text{change in soil moisture} \\ & \text{content above the ZFP} + \text{WCOR} \end{aligned}$$

and drainage is calculated as above, using the calculated evaporation rather than the potential value.

$$\text{WCOR} = \int_{z_1}^{z_2} 1/2 [\theta(z, t_1) + \theta(z, t_2)] dz$$

where z_1 is the ZFP depth at the previous time of soil moisture measurement, t_1 , and z_2 is the ZFP depth at the time for which the calculation is made, t_2 .

If the ZFP either appears or disappears between neutron probe reading dates the evaporation in the input data is assumed for the whole of that interval.

Calculations may be made to start and finish at any time within the year selected, to start with a predetermined cumulative rainfall, and be made for up to 5 depths.

9.1 Running FLUX

Copies of the rainfall, ZFP depth and potential evaporation data files required by FLUX must be available in the same directory as the neutron probe data file. The ZFPFIND program provides files of data in the format required by FLUX. The user must use EDLIN to enter the daily rainfall and potential evaporation data into 2 files. The format of the

first record of these files is :

TYPE (I3) where TYPE is 1 indicating rainfall data, or 3 for potential evaporation data,

SITE (2X,I4) where SITE is a 4 digit number,

YEAR (4X,I2) eg. 85.

The remaining records hold 20 daily rainfall values in F4.1 format, in chronological order. 18 complete records are required (360 days) and a 19th which only holds 6 values. This format corresponds to that of the ZFP depth data file illustrated in the Figure 11. Figure 12 shows the format of a potential evaporation data file.

```

3  58  83
3  3  2  5  4  3  3  4  5  4  4  4  3  5  4  5  5  5  5  3
5  4  4  2  3  2  6  5  7  4  2  8  6  6  6  4  2  4  3  0
3  8 15  0  0  7  7  5  7  7  6  7  7 10  3  3  6  8 12  6
11 6  8  9 14  6 11 12 16 17  7 10 13  9 13 16  2 18 22 13
5  8  5 12 10 14 10 10 12  8  7 13 12 16 11 12 10  6  6 10
6 17 20 18 31 28 12  5 14  7 21 18 23 24 26 25 19 26 25 21
10  8 10 19 24 28 21 18 20 28 21 20 29 32 16 31 18 17 17 20
17 27 22 27 41 26 28 13 20 23 24 25 20 26 35 37 41 37 41 23
26 17 39 38 42 34 28 24 44 47 42 36 18 14 18 42  2 28 30 18
27 36 43 51 56 53 23  0  0  0  0  0  0 41 50 61 52 40  7 23
29 50 46 20 22 26 30 32 51 53 49 30 27 18 42 33 15 18 21 27
0  7 26 39 39 50 46 31 16 46 45 37 36 25  1 17 41 39 32 26
27 26 28 24 22 17 25 38  2 29 14 21 17  5 11 11 10  1 16 18
16 19 18  5 23 23 12 25 25  7 11  8  4  5 16  9 23 18 16  5
10  4 11 12 11  7 15  8 12 13 12 15 11 13 11 15 12  8 11  9
10  9  6  8  6  3  7  7  2  4  3  4  6  5  4  3  5  8  3  0
0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  5  5  4  3
3  2  3  3  2  1  3  1  2  2  0  2  2  2  3  1  2  2  3  3
2  2  1  4  3  0

```

Figure 12. Format of potential evaporation data file.

On running, the program prompts the user to supply the following information : the access tube no., the tensiometer array no., the rain gauge no. and the meteorological station no., the dates between which, and the depths at which, the calculations are to be made, the cumulative rainfall, potential and calculated evaporation values and cumulative drainage values if appropriate, the names of the files holding the ZFP depth, rainfall and potential evaporation data, and of the files in which the drainage values for the depths of calculation specified by the user are to be stored.

TEST

FLUXES MEASURED FROM ACCESS TUBE 1158 TENSIDMETER SET1158 DEPTH 1.00M

DATE	DAY	NDAYS	ZFP	EVAP	WATER	WATER	ZFP	RAIN	ET	EVAP0-	DRAINAGE	CUMULATIVE	CUMULATIVE	CUMULATIVE	CUMULATIVE
	NO		DEPTH	INPUT	ABOVE ZFP	BELOW ZFP	CORR			RATION		RAINFALL	ET	EVAPORATION	DRAINAGE
			MM	MM	MM	MM	MM	MM	MM	MM	MM	MM	MM	MM	MM
4 183	4		.00		.0	308.6						.0	.0	.0	.0
10 183	10	6	.00	2.4	.0	311.0	.0	9.7	2.4	2.4	4.9	9.7	2.4	2.4	4.9
17 183	17	7	.00	2.9	.0	309.7	.0	7.3	2.9	2.9	5.7	17.0	5.3	5.3	10.6
25 183	25	8	.00	3.3	.0	307.5	.0	3.9	3.3	3.3	2.7	20.9	8.6	8.6	13.4
31 183	31	6	.00	2.7	.0	304.6	.0	2.9	2.7	2.7	3.1	23.8	11.3	11.3	16.4
7 283	38	7	.00	3.4	.0	322.1	.0	28.1	3.4	3.4	7.2	51.9	14.7	14.7	23.6
14 283	45	7	.00	3.3	.0	317.2	.0	18.1	2.3	3.3	19.8	70.0	18.0	18.0	43.4
22 283	53	8	.00	4.6	.0	310.5	.0	.0	4.6	4.6	2.0	70.0	22.6	22.6	45.4
1 383	60	7	.00	4.9	.0	311.1	.0	10.2	4.9	4.9	4.7	80.2	27.5	27.5	50.2
8 383	67	7	.00	6.0	.0	305.6	.0	.5	6.0	6.0	.0	80.7	33.5	33.5	50.2
15 383	74	7	.44	8.6	129.3	170.8	.0	2.0	8.6	8.6	-1.1	82.7	42.1	42.1	49.1
22 383	81	7	.00	9.3	.0	305.4	.0	9.8	9.3	9.3	-4.8	92.5	51.4	51.4	44.2
29 383	88	7	.00	6.4	.0	310.9	.0	13.2	6.4	6.4	1.3	105.7	57.8	57.8	45.6
12 483	102	14	.00	13.9	.0	323.8	.0	53.9	13.9	13.9	27.1	159.6	71.7	71.7	72.7
19 483	109	7	.00	13.1	.0	324.6	.0	23.5	13.1	13.1	9.7	183.1	84.8	84.8	82.3
28 483	116	9	.00	17.7	.0	315.6	.0	24.5	17.7	17.7	15.8	207.6	102.5	102.5	98.1
10 583	130	12	.00	23.0	.0	307.7	.0	20.9	23.0	23.0	5.7	228.5	125.5	125.5	103.8
17 583	137	7	.00	17.7	.0	319.5	.0	34.4	17.7	17.7	4.9	262.9	143.2	143.2	108.7
24 583	144	7	.00	13.8	.0	317.0	.0	24.3	13.8	13.8	13.0	287.2	157.0	157.0	121.8
2 683	153	9	.00	22.7	.0	322.7	.0	35.1	22.7	22.7	6.7	322.3	179.7	179.7	128.4
7 683	158	5	.42	15.9	125.0	179.1	.0	5.8	15.9	15.9	8.6	328.1	195.6	195.6	137.0
14 683	165	7	.67	.0	188.1	94.4	80.4	1.0	22.1	18.3	4.2	329.1	217.7	213.9	141.2
21 683	172	7	1.23	.0	331.7	-68.5	162.7	.5	26.1	19.7	.3	329.6	243.8	233.6	141.4
28 683	179	7	1.39	.0	367.7	-117.4	50.1	1.2	15.8	15.3	-1.3	330.8	259.6	248.9	140.2
5 783	186	7	1.43	.0	378.2	-129.0	12.3	15.1	26.1	16.8	-.7	345.9	285.7	265.7	139.5
12 783	193	7	1.45	.0	377.8	-133.1	6.1	11.2	7.6	17.7	-2.0	357.1	293.3	283.4	137.5
18 783	199	6	1.56	.0	440.2	-166.1	34.1	24.7	24.4	-3.6	-1.1	381.8	317.7	279.9	136.4
27 783	208	9	1.53	.0	438.6	-156.8	-9.4	30.5	25.3	22.7	.1	412.3	343.0	302.6	136.5
10 883	222	14	1.53	.0	348.6	-98.7	.0	17.0	41.6	107.0	-58.1	429.3	384.6	409.5	78.4

TOTAL NUMBER OF DAYS = 218

DAYS WITH NO ZFP = 154 70.6%

DAYS WITH ZFP = 64 29.4%

TOTAL EVAPORATION = 409.5 MM

EVAP WHEN NO ZFP (POT EVAP USED) = 195.6 MM 47.8%

EVAP DURING ZFP PERIOD = 213.9 MM 52.2%

TOTAL DRAINAGE = 78.4 MM

DRAINAGE WHEN NO ZFP = 137.0 MM 174.7%

DRAINAGE DURING ZFP PERIOD = -58.6 MM -74.7%

Figure 13. Program FLUX data sheet.

Figure 15. Drainage output file.

DR 1983 TUBE-1158 TENS-1158 DEF-1.00 EVAP-0058 RAIN-0058 CAL 1-1-1980

Figure 14. Evaporation output file.

[illegible]

10.0 EVAPL

This program calculates water fluxes from a lysimeter profile for which neutron probe, rainfall and values for drainage losses from the base of the profile are available. The calculations are performed for a period of up to one calendar year. EVAPL is based on the FLUX program and operates in a very similar manner. A listing is produced (Fig.16) and a file holding the calculated actual evaporation values; the filename is of the form XXXXYR.EVL, where XXXX represents the access tube number and YR the year for which the program is run.

Actual evaporation losses are calculated as follows :

$$\text{evaporation} = \text{cumulative rainfall} - \text{change in soil moisture content} - \text{drainage.}$$

PROGRAM FLUX VERSION 5.3

PROCESSED ON 1- 1-1980

TEST

FLUXES MEASURED FROM ACCESS TUBE 1158 TENSIO METER SET1158 DEPTH 1.00M

DATE	DAY	NDAYS	ZFP	EVAP	WATER	WATER	ZFP	RAIN	ET	EVAPOR-	DRAINAGE	CUMULATIVE	CUMULATIVE	CUMULATIVE	CUMULATIVE
	NO		DEPTH	INPUT	ABOVE	ZFP	BELOW	ZFP	CORR	RATION		RAINFALL	ET	EVAPORATION	DRAINAGE
			MM	MM	MM	MM	MM	MM	MM	MM	MM	MM	MM	MM	MM
4 183	4		.00		.0	308.6						.0	.0	.0	.0
10 183	10	6	.00	2.4	.0	311.0	.0	9.7	2.4	2.4	4.9	9.7	2.4	2.4	4.9
17 183	17	7	.00	2.9	.0	309.7	.0	7.3	2.9	2.9	5.7	17.0	5.3	5.3	10.6
25 183	25	8	.00	3.3	.0	307.5	.0	3.9	3.3	3.3	2.7	20.9	8.6	8.6	13.4
31 183	31	6	.00	2.7	.0	304.6	.0	2.9	2.7	2.7	3.1	23.8	11.3	11.3	16.4
7 283	38	7	.00	3.4	.0	322.1	.0	28.1	3.4	3.4	7.2	51.9	14.7	14.7	23.6
14 283	45	7	.00	3.3	.0	317.2	.0	18.1	3.3	3.3	19.8	70.0	18.0	18.0	43.4
22 283	53	8	.00	4.6	.0	310.5	.0	.0	4.6	4.6	2.0	70.0	22.6	22.6	45.4
1 383	60	7	.00	4.9	.0	311.1	.0	10.2	4.9	4.9	4.7	80.2	27.5	27.5	50.2
8 383	67	7	.00	6.0	.0	305.6	.0	.5	6.0	6.0	.0	80.7	33.5	33.5	50.2

Figure 16. EVAPL data sheet.

10.1 Running EVAPL

The program requests the user to supply the same information as specified for FLUX, except for the tensiometer array no. and name of the ZFP depth and drainage output files. However, the name of the file holding the daily profile drainage data to be used in the run is also required. The user must use EDLIN to edit the drainage data into the file using the same format as that for the rainfall data file described above. In the first record of the drainage data file TYPE should equal 4.

11.0 FURTHER PROGRAMMING

The aim of this Section is to describe how the data stored in the files produced by the programs described in the preceding pages may be accessed for other purposes.

11.1 Sequential data files

The sequential data files used and produced by programs ZFPFIND, FLUX and EVAPL (XXXXYR.ZFP, XXXXYR.EVA, rainfall and drainage data files), all hold data in a similar format. These data are therefore readily accessible by other FORTRAN or BASIC programs. Listings of the different types of file have been illustrated in the Sections corresponding to the relevant program descriptions. The basis of their formatting is that one year's worth of daily data should be stored compactly, yet in a legible form. A FORTRAN format of 20F4.1 is used for each record which means that 19 records are necessary to store 366 day's worth of data. (The last record only holds 6 values.)

The format of the first record of these files varies slightly. The XXXXYR.ZFP, evaporation PEN and rainfall data files have a format of :

Data TYPE	(I3)
Site number	(I6)
Year	(I6)

in the first record where TYPE is 1 for rainfall, 2 for zero flux plane depths and 3 for potential evaporation data.

The format of the first record of XXXXYR.EVA files is :

Data TYPE	(4A1)
Year	(3X,I2)
Tube no.	(7X,I4)
Tensiometer array	(7X,I4)
Met. Station	(7X,I4)
Rain gauge	(7X,I4)
Date processed	(7X,I2,1X,I2,3X,I2)

where TYPE is "EVAP". Finally, the format of the first record of the drainage files produced by FLUX is :

Data TYPE	(2A1)
Year	(3X,I2)
Tube no.	(7X,I4)
Tensiometer array	(7X,I4)
Depth metres	(6X,F4.2)
Met. station	(7X,I4)
Raingauge	(7X,I4)
Date processed	(7X,I2,1X,I2,3X,I2)

where TYPE is DR for drainage.

A demonstration program, EXPROBE, has been prepared to illustrate the use of these subroutines. A listing of the FORTRAN code is provided below.

11.3 TENSIO Files

Two subroutines are required :

TDOPEN and TDFIND

and they are similar in operation to NPOPEN and NPFIND described above. The following statements must be included at the beginning of any program using these two subroutines:

```
LOGICAL SITE(4) [ or INTEGER*1 SITE(4) ]  
COMMON /INFO/SITE,IU,ITOT,NDEP,IDEP(29),IZ,MAX,IEXIST  
COMMON /RDATA/IDYMTN,IYR,ITIME,IREAD(29),ICODE(29),NEXIST
```

Before calling the subroutines, a tensiometer array no. must be supplied in 4A1 format in SITE, and IU must be set to any permissible unit no. other than 1, 4 or 5.

CALL TDFIND will return IEXIST 0 in COMMON INFO if the file is successfully opened, and IEXIST 1 if it is not. If the former, the remaining values in INFO are as follows :

ITOT	- no. of sets or readings currently stored in the file,
NDEP	- no. of tensiometers,
IDEP	- the depths of the tensiometers,
IZ	- the zero set correction (cm mercury)
MAX	- the maximum no. of records that could be held in the file.

CALL TDOPEN(IOBS) where IOBS is the no. of the record which it is wished to read returns NEXIST 0 if the record is found, NEXIST 1 if it is not. If NEXIST = 0 then the remaining variables in COMMON RDATA are :

IDYMTN	- day of the month*100 plus month,
IYR	- year,
ITIME	- the time at which the readings were recorded,
IREAD	- the readings (cm mercury),
ICODE	- the status codes corresponding to the readings.

The demonstration program EXTENSIO has been prepared to demonstrate the use of these subroutines and a listing is provided below.

 EXPROBE Program to demonstrate the use of subroutines NPOPEN,
 NPFIND, and CALIB to extract neutron probe reading data from files
 generated by the NPROBE system, and soil moisture calibrations from
 the calibration data file. NPOPEN opens the probe data file and
 reads the first 2 records. NPFIND finds and reads the required set
 of observations. CMKG - July 1985/IH

LOGICAL SITE(4)
 CHARACTER*6 TYPE(2)
 COMMON/INFO/SITE, IU, ITOT, NDEP, IDEP(33), ITYP, MAX, MTUBES(8)
 COMMON/DIRECT/SLP(33), TCPT(33), ICAL(33)
 COMMON/RDATA/IYR, MTHDAY, IPROBE, WKOUNT, ITIME, KTIME, IREAD(33)
 DATA TYPE/"ACCESS", " MEAN "/
 CALL VCLEAR
 WRITE(1,299)

299 FORMAT(" SAMPLE PROGRAM")
 WRITE(1,300)"ENTER THE SITE NUMBER :"

300 FORMAT(/, ' ', A0, \$)
 READ(1,200)(SITE(N), N=1, 4)

200 FORMAT(4A1)
 WRITE(1,300)"ENTER THE OBSERVATION NO :"
 READ(1,201)IOBS

201 FORMAT(1I0)
 WRITE(1,300)"ENTER THE UNIT NO (nb. Any number but 5) :"
 READ(1,201)IU

CALL NPOPEN(IEEXIST)
 IF(IEEXIST.EQ.1) GO TO 505
 WRITE(1)'FILE DOES NOT EXIST'
 STOP

505 WRITE(1,240)

240 FORMAT(1X, ' ')

WRITE(1,250)TYPE(ITYP), SITE, NDEP

250 FORMAT(1X, A6, " TUBE NO : ", 4A1, " NO OF DEPTHS : ", I3)

IF(ITYPE.EQ.1) GO TO 9

WRITE(1,249)(MTUBES(M), M=1, 8)

249 FORMAT(/, " MEAN DATA IS FOR TUBES", 8I5, /)

9 WRITE(1,248)ITOT, MAX

248 FORMAT(1X, "PRESENT NO. OF RECORDS : ", I3, " POTENTIAL NO. : ", I3)
 1HS : ", I3)

CALL CALIB(NDEP)

WRITE(1,251)

251 FORMAT(/, 1X, " DEPTHS CALIBRATION (code, slope and intercept)")

DO 1 N=1, NDEP

1 WRITE(1,252)IDEP(N), ICAL(N), SLP(N), TCPT(N)

252 FORMAT(1X, I6, I10, 2F6.3)

CALL NPFIND(IOBS, NEXIST)

IF(NEXIST.EQ.1) GO TO 506

WRITE(1)'OBSERVATION NO. REQUESTED DOES NOT EXIST'

STOP

506 IDY=MTHDAY-MTHDAY/100*100

MTH=(MTHDAY-IDY)/100

WRITE(1,260)IDY, MTH, IYR, ITIME, IPROBE, KTIME

260 FORMAT(1X, "DATE : ", 3I2, " TIME : ", I5, " PROBE : ", I4, " COUNT TIME : ", I3, " SECS")

WRITE(1,261)

261 FORMAT(/, " PROBE COUNTS")

DO 2 J=1, NDEP

2 WRITE(1,262)IDEP(J), IREAD(J)

262 FORMAT(1X, 2I6)

STOP

END

EXTENSIO Program to demonstrate the extraction of data from
tensiometer data files of the form TDxxxx.DAT. Two subroutines
are required - TDOPEN and TDFIND to open the data file and
read its first record, and to find and read the observation
record required. CMKG July 1985.

LOGICAL SITE(4)
COMMON/INFO/SITE, IU, ITOT, NDEF, IDEP(29), IZ, MAX, IEXIST
COMMON/RDATA/IDYMT, IYR, ITIME, IREAD(29), ICODE(29), NEXIST
CALL VCLEAR
WRITE(1,299)
299 FORMAT(" SAMPLE PROGRAM FOR EXTRACTING TENSIO METER DATA FROM FILES")
WRITE(1,300)"ENTER THE SITE NUMBER : "
300 FORMAT(/,' ',A0,\$)
READ(1,200)(SITE(N),N=1,4)
200 FORMAT(4A1)
WRITE(1,300)"ENTER THE OBSERVATION NO : "
READ(1,201)IOBS
201 FORMAT(1I0)
WRITE(1,300)"ENTER THE UNIT NO (nb. Any number greater than 4) : "
READ(1,201)IU
CALL TDOPEN
WRITE(1,240)
240 FORMAT(1X,' ')
WRITE(1,250)SITE, ITOT, MAX
250 FORMAT(1X,"SITE NO :",4A1,
1 //,1X,"TOTAL NO. OF RECORDS : ",I4," POTENTIAL NO. : ",I4)
WRITE(1,251)NDEF, IZ
251 FORMAT(/,1X,"NO OF TENSIO METERS ",I3," ZERO SET CORRECTION.",I3)
CALL TDFIND(IOBS)
IF(NEXIST.EQ.0) GO TO 20
IDY=IDYMT/100
MTH=IDYMT-IDY*100
WRITE(1,260)IDY, MTH, IYR, ITIME
260 FORMAT(//," DATE : ",3I2," TIME : ",I4)
WRITE(1,261)
261 FORMAT(//," TENSIO METER DEPTHS, READINGS AND STATUS CODES")
DO 2 J=1,NDEF
2 WRITE(1,262)IDEP(J), IREAD(J), ICODE(J)
262 FORMAT(1X,2I6,I3)
20 STOP
END